

Dark Matter and Particle Physics

Physicists believe there are close connections between particle physics and astrophysics. New types of particles could make up the dark matter in galaxies and clusters of galaxies. Such particles (for example supersymmetric particles) would solve long-standing puzzles in particle physics. If they exist, these particles would interact with the rest of matter only weakly, giving off no light, but would be detectable through their gravity.

Dark Energy

At the time of Albert Einstein, astronomers thought that the universe was not expanding or contracting. Einstein knew this was inconsistent with the predictions of gravity. He thought he needed something to counteract the attraction of gravity, so he hypothesized a "cosmological constant" in his general theory of relativity. A few years later, observations showed the universe to be expanding, and he abandoned this idea.

But when very recent measurements discovered the universe to be not only expanding, but expanding more and more quickly (accelerating), the idea of something to oppose gravitational attraction was revived. Physicists have come up with many other ideas besides the cosmological constant that could achieve this, so we don't yet know which type of physics is the real explanation. Since the cause of the accelerating universe is unknown, it is just called "dark energy." Future measurements should tell us whether Einstein's abandoned idea or some other exciting idea is correct.

Attributes of the Universe

Three attributes of the universe at various times in its history are shown in this table. The distance scale (or size scale) reflects expansion of the visible universe. Temperature and energy are characteristics of radiation at a given time.

Time	Distance Scale (m)	Temperature (K)	Energy (MeV)
10^{-43} s	10^{-31}	10^{32}	10^{22}
10^{-12} s	0.1	10^{16}	10^6
10^{-4} s	1000	10^{12}	100
10^2 s	10^{10}	10^9	0.1
4×10^5 y	10^{21}	3000	3×10^{-7}
3×10^8 y	10^{24}	30	3×10^{-9}
Today	10^{26}	3	3×10^{-10}

Recommended Reading

More information about the content of this chart appears in an article by Lawrence Krauss (author of *The Physics of Star Trek*) in the March 2003 issue of *The Physics Teacher* magazine.
<http://UniverseAdventure.org/krauss>

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